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AVIATION PETROLEUM WITH BIOFUEL AND ITS EFFECT ON RUBBER GASKET OF FLYING MOTORS

M. OLŠOVSKÝ[1*], M. HOCKO[2], G. URBAN-KHOCHARYAN[1], J. KRAJČI[1], A. ČEKANOVÁ[2]

[1] *Faculty of Industrial Technologies, Alexander Dubček University of Trenčín; Púchov, Slovakia, contact author: olsovsky@fpt.tnuni.sk*
[2] *Faculty of Aeronautics, Technical University Košice; Košice, Slovak Republic, marian.hocko@tuke.sk*

ABSTRACT: One of the Project parts of BIOPAL (Biofuel for aviation) realized under the conditions of the Department of Aviation Engineering, the Faculty of Aeronautics, Technical university in Košice in cooperation with Faculty of Industrial Technologies TnUAD in Púchov, have focused on the results of long-lasting influence of various concentrations of biofuel mixtures MERO (methylesters of rapsol oil acids) and aviation petroleum JET A1 on sealing elements of air turbo-compressor engine. The introduced results of the experiment analysis have definitely proved negative effects of the bio-fuel MERO and aviation petroleum Jet A1 mixture on rubber sealings used in construction of aviation engines. Ignoring introduced facts can have significant influence on a safety level in aviation. Examples from the history of aviation and astronautics show that a crash can be caused even by consequences of a damage of such an elementary element as sealing, what also happened to a perfect machine like an American shuttle was. This is the reason why it is so important to investigate perfectly the effects of biofuels on individual components of aviation engines and to accept such measures for construction which would limit possible negative results before headless transition to using biofuels in aviation engines.

KEY WORDS: MERO, biofuels, aviation petroleum JET A1, rubber sealings, physical-mechanical properties

1. INTRODUCTION

1.1 Biopetroleum „MERO“

Biopetroleum „MERO“ of the 2nd generation is still the only alternative fuel which is generally used for petroleum engines. It even overcomes conventional engine petroleum with its parameters and especially in the relation to a fuel system and engine wear. Same as each alternative fuel, biopetroleum has its advantages and disadvantages.

Biopetroleum has a high lubricant power (it is more lubricant than petroleum), so it decreases wear of friction engine parts and prolongs service life of fuel injection nozzles. The lubricant power of petroleum is extra important because some engine parts are greased directly by fuel and not by oil. Biopetroleum does not require any special storage conditions. It is possible to store it in the same type of containers as petroleum is stored. Biopetroleum has better burning properties in the burning process and therefore it significantly decreases effects of engine smoking, amount of solid parts, sulfur, carbon dioxide, aromatic matters and hydrocarbons in general. Thanks to its structure, biopetroleum is reducible in 21 days and that is why it is suitable for operations where contamination of soil is caused by fuel i.e. especially in agriculture and forest production, in water utilization protection zones etc. Biopetroleum is considered to be so called cleaner – having a power to release carbon and it perfectly cleans an engine and all fuel systems and prevents sedimentation of fuel filters. When biopetroleum is stored it is necessary to insure clearness of storage space and protect biopetroleum from contact with water. The long-lasting storage of biopetroleum is not recommended, since there is a possibility of decomposition of its plant parts. It is aggressive towards rubber, easily oxidizing with following creation of sediments and acid products. It is easily attackable by bacteria.

1.2 Aviation petroleum „Jet A1"

Aviation petroleum „Jet A1" is a mixture of liquid hydrocarbons which boil mainly up to the temperature of 275 °C. It is clear liquid with typical kerosene smell. In order to increase utility features it embodies special additives. The basic additive package includes antioxidant, antistatic and lubricant additives. It can also include other additives which are suitable for operations of aviation technologies and which are approved by responsible aviation authorities. Aviation petroleum is the 2nd threat inflammable class. It can have irritable effects on human organism and it can evoke skin changes. It does not vapour in normal temperature, but its vapours formatted in higher temperatures have narcotic effects. It also degreases the skin. In manipulation with this matter it is recommended to keep instructions written in the Material Safety Data Sheets (MSDS).

Slovnaft, Inc. delivers the following sorts of aviation petroleum to a business market:
- Aviation petroleum JET-A1 with a quality set according to PN 25-002-02, (end of distillation in 300 °C, inflammation point at least 40 °C).
- Aviation petroleum PL-7 with a quality set according to PN 25-005-02, (end of distillation 275 °C, inflammation point at least 50°C).

Physical qualities of the biofuel MERO and aviation petroleum Jet-A1 are very similar. The investigation of possibilities to mix the biofuel MERO and aviation petroleum Jet-A1 has discovered, that the same mixture without sediments or coagulants is created in all concentrations (from 0% up to 100%) of the biofuel MERO contained in aviation petroleum Jet-A1. Despite the fact that the created mixtures with various concentrations of MERO included in aviation petroleum did not have, even after a year of investigation, a tendency to return separation of the MERO fuel heavy component (ρ_{MERO} = 882 kg.m^{-3}) from the easier aviation fuel component Jet A-1 ($\rho_{Jet\ A-1}$ = 810 kg.m^{-3}), it is necessary to perform durable testing in different temperature conditions.

2. EXPERIMENT

Even though in some cases can tests simulate operational conditions quite well, we cannot always expect direct connections between lab test results and results achieved from some practical usage. In order to perform tests, we have to take into consideration rubber thickness, since the speed of liquid penetration depends on time [1,2]. Inner volume of a product with big thickness can stay unaffected during the whole time of its defined lifetime. It is also known that the liquid affecting the rubber, especially in high temperatures, can also be affected by air oxygen [2,3].

The analyses of samples were directed especially on effects of the biofuel „MERO" and aviation petroleum „Jet A1" mixture on physical and mechanical parameters of sealings. The samples of sealings were exposed to various concentrations of fuel mixtures for 12 months [6,7]. After this time, samples were taken out of liquid and their basic physical and mechanical parameters were measured. Determination of physical and mechanical parameters was performed according to a norm testing included in STN [4]. A table scieroscope IRHD with an accuracy of ± 0.5 IRHD was used to measure the hardness.

It is obvious from the measured values, that when the volume of the bio-fuel MERO (Acid Metylester of Coleseed oil) increases the resistance of fuel, mixture decreases. Resistance decreased practically for about 100 % in the clear fluid „MERO". Hardness of the sample 1 (100 % Jet A1) is even higher than hardness of the standard. Presumably this is caused by aviation petroleum „Jet A1"structure, which includes different mixtures of organic adducts. Aviation petroleum does not attack the rubber as plasticizer or diluents but vice versa. Rubber contained in aviation petroleum is reduced and thereby its hardness increases. On the contrary, when a bio-fuel „MERO" additive increases, the sample hardness decreases. It is caused by the fact that metylesters of greasy acids of Coleseed oil effect the India-rubber matrix as inner plasticizer (it increases mobility of macro molecules). The distances among macromolecules enlarge and thereby the sample's resistance decreases.

Solidity characteristics (tension strength in breakage and tenseness) were measured according to STN ISO 37 [4]. The INSTRON shredder was used in the laboratory temperature for testing with clutch movement speed of 100 $mm.min^{-1}$. It is evident from the chart, that solidity of samples decreases proportionally with the increase of amount of the bio-fuel „MERO" content in the mixture with the aviation petroleum „Jet A1". The values of solidity characteristics decrease more expressively if there is more than 20 % of bio-fuel in the mixture. The decrease of resistance is caused by bio-fuel "MERO" attacking India-rubber mixture and having effect of plasticizer. When samples of mixtures had higher content of bio-fuel „MERO" (more than 50 %), sealings were so damaged by attacking fuel that it was not possible to clamp them into the shredder and to measure solidity characteristics. This happened because in lower level of bio-fuel „MERO" mixture with aviation petroleum „Jet-A1", both of the samples got in contact with air oxygen which speeded up the process of degradation. It has explained why some samples, despite the higher concentration of „MERO" fuel attacking them, were not so degradated as samples effected by air oxide.

Tab. 1: Effects of aviation petroleum Jet A1 and bio-fuel MERO on weight changes of samples

Sample	Solution content [wt. %] MERO : JET A1	Change of a sample weight [g]		
		After 3 days	After 7 days	After 10 days
1	0 : 100	0.03837	0.03224	0.0118
2	10 : 90	0.02546	0.02139	0.00343
3	20 : 80	0.01179	0.00847	0.00412
4	30 : 70	0.03785	0.03283	0.02854
5	40 : 60	0.03719	0.03252	0.03174
6	50 : 50	0.04345	0.04065	0.03916
7	60 : 40	0.03928	0.03731	0.03584
8	70 : 30	0.05405	0.05417	0,05593
9	80 : 20	0.05190	0.04913	0.05301
10	90 : 10	0.05069	0.05093	0.05026

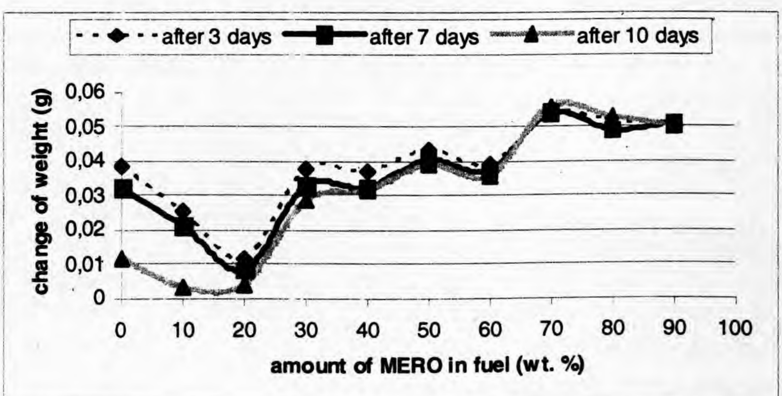

Fig. 1: Dependence of weight changes on MERO content in a fuel

From the measured values shown in Tab. 1 follows, that up to 20 % of „MERO" contained in the mixture with aviation petroleum „Jet A1" causes that the weight of a sample decreases compared to the original state. Due to rubber made structure we suppose, that an India-rubber matrix has the ability to "accept" certain amount of plasticizer („MERO"). Effects of soaking up and partial destruction of a rubber sample commence when there is more than 20 % of „MERO" contained in the mixture with the aviation petroleum „Jet A1".

The change of a sample weight increases practically linearly with the increasing content of the bio-fuel „MERO" in the mixture with aviation petroleum Jet A1" (above 20 %). The increase of sample weight of rubber sealings in dependence on effecting time of a fuel is practically the same after 3, 7 or 10 days (Fig. 1). Therefore the change of weight is primarily affected by the „MERO" bio-fuel structure in the mixture.

3. CONCLUSIONS

Introduced results of the experiment analysis have definitely proved negative effects of the bio-fuel „MERO" and aviation petroleum „Jet A1" mixture on rubber sealings used in a construction of aviation engines. Ignorance of introduced facts can have significant influence on safety level in aviation. Examples from the history of aviation and astronautics show, that a crash can be caused even by consequences of a damage of such an elementary element as a sealing, which happened to a perfect machine like an American shuttle was. From this reason it is very important to investigate perfectly the effects of biofuels on individual components of aviation engines and to accept such measures for construction which would limit possible negative results before headless transition to using bio-fuels in aviation engines.

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